M. diffusa. Alongside walks and in shady places covering the ground. Leaves very short and nearly at right angles with the stem.

*M. ———. River bank, Osawatomie. Mr. Wood cannot find the same. He thus describes it: "Slender, glabrous, branching, one foot high; panicle erect, capillary, loose, branches in 3's and 5's, whorled. Spikelets scarcely 1″ long, much shorter than their pedicels. *Glumes pointed, rough on the keel, the upper one shorter, but longer than the two equal obtuse 3-veined pales*, which have a few short beards at their base. Comes nearest to M. Mexicana, but is decidedly different by the characters italicized."

Calamagrostis, Reed Bent-grass.

C. Canadensis, Blue Joint. One place, Wakarusa bottom.

Paspalum.

P. fluitans. Mostly under water. Osawatomie.

Panicum, Panic Grass.

P. proliferum.
P. agrostoides.
P. viscidum. Snow and Saunders.

Bromus, Brome Grass.

B. secalinus, Chess.
B. mollis, Downy Chess.
B. ciliatus.

Tricuspis.

T. (Uralepis) purpurea.

Dactylis, Orchard Grass.

D. glomerata.

Festuca, Fescue Grass.

F. ovina, Sheep's Fescue.
F. pratensis, Meadow Fescue.
F. elatior.

Eatonia.

E. obtusata.

Melica, Melic Grass.

M. mutica. Scattered, tall, conspicuous.

Eragostis.

E. reptans. Riverbank, Osawatomie.
E. purshii.
E. erythrogona. Seen once.

Poa, Spear Grass.

P. compressa.
P. sylvestris. Both have flattened stems.

Glyceria, Manna Grass.

G. nervata.
G. maritima.

Triticum, Wheat.

T. violaceum. Distinct from T. repens or or Couch Grass.

Leptochloa.

L. mucronata. Osawatomie.

Eleusine, Yard Grass.

E. Indica. Yard of Presbyterian church, Lawrence.

Buchloe, Buffalo Grass.

*B. dactyloides. Ellis. Watson.

A grass called by this name grows near Osawatomie, but it seldom or never blossoms, so that it would require close observation to determine it. It grows in stools as Buffalo grass is said to, and is of about the same size.

Filices, Ferns.

Polypodium. Polypody.

P. incanum. Burlington. Mrs. J. N. Locke.

Aspidium, Shield Fern.

A. spinulosum, var. Boottii. Lawrence. Saunders.

HEPATICAE.

Marchantia.

*M. polymorpha. Saunders.

Species added, about 175.

Not east of Mississippi, about 27.

LAWRENCE, KANSAS, Dec., 1873.

SPECULATIONS IN REGARD TO COMETS' TAILS.

BY F. W. BARDWELL.

Of all questions in Astronomy pressed conspicuously upon notice, none seem to elude the grasp of the scientist with more subtlety than that of the character and composition of comets' tails. From Copernicus to Newton, from Newton to Le Verrier and to the spectroscopist of to-day, are seen a series of brilliant triumphs. The Ptolemaic epicycles have vanished into the simplest of curves; the multitudinous array of celestial orbs follow each other with infinite precision and never-ending succession, according to laws comprehensible

almost by a child. The perturbations of Uranus have responded to the interrogations of Le Verrier and Adams, and our sun and the more distant suns, though they tarry not in their courses at the command of any modern Joshua, yet reveal to the searching gaze of the spectroscopist the secrets of innumerable ages, and declare their common membership of one illimitable system.

Such are the conquests of astronomers; and yet an intruder, as it were, rushes impetuously into the insignificant domain of our own solar system, and, it may be, with a passing nod to Jupiter, whirls angrily around the sun, whose proximity seems to kindle a fiery train, then retreats as suddenly as he appeared, departing with regal courtesy, never turning the back toward the gaze of his august majesty, the Sun, and at his disappearance leaves the ignorant beholder terrified, and the startled philosopher bewildered.

Let us glance briefly at the more important facts, and try to find out their significance. Comets are those bodies moving around our sun in orbits of considerable eccentricities. Perhaps this characteristic is the most decisive of those which serve to distinguish them from other members of our solar system, though the classification may really be empirical. There is, indeed, great diversity in the phenomena attending different comets. Some accomplish their revolutions in three or four years; others in three or four thousand years; others still in a hundred thousand years; and finally, it is thought some never revisit our solar system. Many comets have tails, so called, while others have none; and still others are surrounded by envelopes of a hazy or misty appearance. Some of the so-called tails have been of remarkable extent, and in general have followed the comets in approaching the sun, and preceded them in going away, attaining their maximum soon after passing perihelion. This it is that has so puzzled astronomers. The nucleus evidently obeys the law of gravity, but in passing perihelion the tail sweeps around contrary to that law, and with a vivacious energy that would laugh gravity to scorn.

It has been suggested that the matter composing the comets' tails differs essentially from that of the nucleus, being of a nebulous character, or at any rate in a nebulous condition; though the exact nature of this character or condition of matter no one could define, but it was thought to be misty-like, or vaporous and extremely rarefied. It was further thought that some repulsive force, emanating in the sun, acted on the nebulous fog of the tail, while it did not act on the nucleus, thus giving to the sun a double-dealing character, blowing hot and blowing cold at the same time, quite at variance

with his usual character for consistency. Bessel computed the form and motion of the comets' tails subject to such a repulsive force in the sun; and after him, Pierce. Bessel supposed that the material elements of the tail were developed from the nucleus, flowing away from it and soon lost to it; that is, became separated from it so far that the attraction of the nucleus no longer had an appreciable effect upon them, while the repulsive force of the sun carried them off still further and dissipated them entirely from view. But this hypothesis involves the difficulty of supposing that the same matter which originally formed a part of the nucleus, and as such moved subject to the attractive force of the sun, afterwards becoming evolved from the nucleus, was then repelled by the force of the same sun with an increased energy.

Now a change in the molecular condition of the elements of a body may often develop repulsion among those elements, as for instance, the ignition of powder or even an increase of temperature, and so we may understand the development of a repelling force whose center is situated within the nucleus; but in Bessel's hypothesis the center of the repellant force is supposed to be in the sun, millions of miles away.

Though Bessel's hypothesis may have given way in the light of more recent investigations, yet a statement of it in this place may help to present in a clearer light the real difficulties in the problem before us. And in looking for all the facts that may have a bearing on the question, let us not forget that the space between the sun and planets, and even that between our solar system and other systems, cannot be absolutely void, for light, whether it come from our sun as the bright harbinger of day, or whether it come in the faint twinkling that reaches us after a tireless flight of centuries, in either case travels along the waves of celestial ether of unbroken continuity. Where the terrestrial atmosphere fades away, or at what limits the solar atmosphere loses itself in the ethereal depths, we know not; yet it has been clearly established that flames of meteors become visible in the neighborhood of the earth at a greater distance from the earth than the supposed limits of our atmosphere, these flames apparently resulting from the resistance of the medium through which the meteors pass; and the zodiacal light, evidently a solar phenomenon, indicates the existence of a belt of luminous matter, or of matter that may become luminous, extending around the sun, even outside the earth's orbit.

Next in order may be mentioned the interesting relation recently shown to exist between some of the comets and periodic meteors

Thus, Tempel's comet of 1865, and the November meteors, are said to have the same orbit; that is to say, the orbits are so nearly identical that they indicate a common origin. In a similar way it is found Tuttle's comet of 1862 moves along in company with the August meteors, and the bright comet of 1861 moves in company with a less conspicuous group of April shower-meteors.

Oppolzer, Peters, Weisse, Le Verrier and others have contributed to these results; but Schiapparelli, of Milan, has been the most active, both in obtaining results and interpreting them, and his theory is favorably received. Nebulæ is a name given to bodies of cosmical matter in that diffuse condition in which it is supposed the material of the solar system once existed, when it occupied continuously all the space from its center far beyond the limits of Neptune's orbit. Schiapparelli supposes that among such cosmical clouds, floating in space, it occasionally happens that one comes within reach of the sun's attractive influence. The attraction acts more powerfully on the nearer portion, and while the nebula is still at a great distance, it begins to lose its spherical form, becomes elongated and somewhat cylindrical, the foremost part becoming denser and more pointed. As it approaches nearer the sun the transformation becomes more complete, the part nearest the sun becoming a dense nucleus, and the part following forms the tail, curved in consequence of the lateral motion preserved by the nebula during its progress.

Thus we have a comet moving in an orbit whose eccentricity and plane depend upon the initial circumstances. The comet is not, however, a solid mass, but consists of particles, each possessing an independent motion, and the comet becomes more elongated, and at last is resolved into a ring of meteors. In the course of time the matter composing a comet, which completes its revolutions around the sun, must be dispersed over the whole path. Schiapparelli affirms that the comet of 1862, No. III, is simply the remains of the original comet, out of which the meteoric ring of the 10th of August has been formed in the course of time. Le Verrier, adopting the this theory, traces the history of the comet of 1866, No. I, first discovered by Tempel. A cosmical nebulous cloud he thinks entered our system in January, 126, and happening to pass near the planet Uranus was brought by its attraction into an elliptic orbit around the sun. This orbit is that of Tempel's comet, and identical with that of the group of November meteors. He supposes this meteoric cloud became visible as a comet in 1866 for the first time. The tail of this comet is composed of the multitude of small meteoric

bodies which follow the nucleus, and as our earth encounters them for three successive years, the tail must have a length of nearly eighteen hundred millions of miles. Such, in brief, is the theory of comets and their tails, as advocated by Schiapparelli and Le Verrier, but it seems to leave the original difficulties, with no diminution of their force.

This theory seems to offer no satisfactory explanation of the mode by which the material elements of the tail are seen first to follow the nucleus; then, near perihelion, to be chiefly outside the orbit; and finally, to be in advance of the nucleus. Spectrum analysis has in a wonderful manner enabled astronomers to penetrate long-hidden secrets; and naturally, this agent has been summoned to aid in the solution of this question. So far, however, the opportunities to make this agent available in the examination of comets have been limited. Donati was the first, in 1864, to study spectroscopically the light of comets; and recently Secchi, Huggins, and others have given their attention to the same object. No brilliant comet has in the meantime appeared; and the results obtained, which chiefly pertain to the nucleus only, though of importance, may be briefly stated. It seems then clearly established by spectrum analysis, that the nucleus of a comet is self-luminous, and that the luminous portion is glowing gas — in some instances carbon being present. It is also probable that the luminous nucleus may in a slight degree reflect sunlight. Scarcely more than this has yet been determined by means of the spectroscope; but the appearance of any bright comet will be the occasion of the most attentive observations, and we may hope then for a complete solution of this interesting puzzle.

In the meanwhile, waiting thus for the return of such a far-wandering messenger, even now on the way laden with news, we can only indulge in speculations; and I venture to offer some of these that point, it may be, toward a solution — speculations that may subsequently be verified, or subsequently prove to be fallacious.

Allusion has already been made to the zodiacal light, which indicates the existence of a belt of luminous matter, or of matter that may become luminous, extending far out from the sun. The motions of Encke's comet indicate a resisting medium, and let us suppose this granted. In accordance with this hypothesis, observation shows that for the same comet the display of a brighter train occurs, with an increased velocity and diminished distance from the sun, the cumulative effects of which reach a maximum only after perihelion passage. For different comets, so far as other conditions coincide, the same principle is verified.

We have seen, too, that comets and meteors appear in some instances to have a common origin, and that meteors are composed chiefly of elements well known, though it is probable that the more volatile elements become entirely separated in passing through our atmosphere from the more solid portion which actually reaches the surface of the earth.

Let us suppose, then, that we have merely a larger mass of meteoric matter, possessing in its composition some elements capable of volatilization, moving in such an orbit as any of the comets are observed to have ; then, with the exception of the tail, all the phenomena of a comet would naturally follow, according to the different circumstances supposed. Entering the resisting medium more or less heat would be developed, according to the velocity, which would increase as the mass approaches the perihelion, while the resistance and heat would increase still more rapidly, attaining a maximum soon after passing that point. The heat thus developed and probably increased by the proximity of the sun, would tend to volatilize some of the elements of the body, causing them to become luminous and present the phenomena of the corona and the nucleus. It is possible, too, that some of the elements of the medium through which the body is moving would share in and increase the luminosity.

Now, with regard to the tail, it has been heretofore assumed that the train so designated, often accompanying a comet, is an essential part of it. Bessel thought, as we have seen, that the material elements of the tail were derived from the nucleus flowing from it, and then repelled by a force centered in the sun. Schiapparelli and Le Verrier think these elements are of the same kind of substance as that of the nucleus, but in a more diffuse condition, and becoming luminous by some motion among themselves.

But may it not be possible that this train of light which accompanies a comet, and has been called a tail, is in fact, no part of the comet more than a shadow is a part of the object which gives it form ? May it not consist of particles of the medium through which the comet passes, made luminous by the rays of the sunlight acted on by the glowing gas of the corona? If the zodiacal belt forms this medium, in whole or in part, being already slightly luminous, its luminosity (it is possible to imagine) might be easily increased.

How the phenomenon of light is actually produced, we do not know. We know that the flames of certain gases give rise to it that is, cause the necessary undulation of the ether, and we know that our sun is the source of a large supply of light, and, though we

may know some of the attendant circumstances in these cases, yet who can tell the circumstances that give rise to auroral light, or who can tell the origin of zodiacal light?

So we may see the phenomenon of light in the train that accompanies the comet, and, though we may not be sure of all the conditions that take place, yet it seems highly improbable that this luminous mist forms any part of the comet, and I predict that when a brilliant comet gives an opportunity to apply the tests of spectrum analysis, it will appear that this bright train is not nebulous, as Bessel thought, and is not diffuse meteoric matter, as Schiapparelli and Le Verrier have supposed, but is the illumination of the medium through which the comet is passing.

In closing, let us notice several facts that have interest in this connection:

It was thought highly probable that the earth passed through a portion of the tail of the bright comet of 1861, on the 30th of June, of that year. The effect was apparently to dim slightly the light of the sun before sunset, and at the same time to give the sky an "auroral, glare-like look." The comet itself, in the evening, had a more hazy appearance than at any other time after that evening. These incidents seem inconsistent with the theory of a meteoric composition of the tail, but more consistent with the hypothesis of a luminous shadow formed by but not a part of the comet. In 1807 and again in 1811, Chladni, a careful observer, noticed what he styled a prodigious ebullition proceeding from the nucleus to the extremity of the tail of a comet, in a few seconds of time. The tail of the comet of 1811 was estimated to extend four millions of leagues, and light itself travels no faster. It was as if the waves of ether were made visible in their undulations.

A few words with regard to the resistance of a medium, and I close. Only the orbits of short-period comets have been determined with any approach to accuracy; and of these, Encke's has the least perihelion distance. This comet, too, has a shortening of its period, apparently in consequence of the resistance of the medium through which it passes. Is it not probable, too, that such a resistance is the explanation of some of the irregularities of the comets of long period? Thus the comet of 1264 and 1556 was expected to return in 1848. May it not be that the comet of 1843 was the identical one with its period shortened? The comet of 1843 passed very near the sun; nearer even than Encke's comet. Arago made a study of the records of Halley's comet, to determine if possible whether in its successive reappearances it had lost any of its brilliancy. He

thought it had lost nothing. May not this again be due to the probable fact that in successive returns the comet approaches nearer the sun, encounters more and more of the resistance of the medium, and therefore tends to develop more fully the phenomena of the tail, which would otherwise be less developed, because the nucleus must be losing some of its volatile elements?

Thus questions of interest press upon us, and astronomy, though the oldest of the sciences, is ever opening new and attractive fields of study.

METEOROLOGICAL SUMMARY FOR THE YEAR 1873.

PROF. F. H. SNOW'S ANNUAL REPORT AS METEOROLOGIST TO THE STATE BOARD OF AGRICULTURE.

Station, Lawrence, Kansas. Latitude 38°, 58′; longitude 95°, 16′. Elevation of barometer and thermometers, 884 feet above the sea level and 14 feet above the ground; rain gauge on the ground; anemometer 105 feet above the ground, on the dome of the University building.

TEMPERATURE.

Mean temperature of the year 52.71°, which is 0.17° lower than the mean temperature of the five preceding years. Notwithstanding this very near approximation of the mean yearly temperature to the mean of past years, the range of temperature was much greater than in any previous year of our record, amounting to 130°. The extremes were 26° below zero January 29, and 104° above zero August 29 and 30. These extremes were respectively 8° lower and 1° higher than any indications of former years. Mean temperature at 7 A. M., 46.15°; at 2 P. M., 61.80°; at 9 P. M., 50.18°.

Mean temperature of the winter months, 26.75° (2.46° below the average); of the spring, 52.10° (1.62° below the average); of the summer, 78.06° (2° above the average); of the autumn, 53.37° (1.28° above the average).

The coldest month of the year, also the coldest month on our record, was January, with mean temperature 18.61°; the coldest week was January 23-29, mean temperature only 2.60° above zero; the coldest day was January 28, with mean temperature 13° below zero. The night of January 28-29 was excessively cold, the mean of seven observations taken at intervals during the night being 22.5° below zero.